Online Exam Proctoring System

Submitted in partial fulfillment of the requirements

of the degree of

Bachelor of Engineering

By

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CERTIFICATE

This is to certify that the project entitled **"Online Exam Proctoring System"** is a bonafide work of **"Bhumit Malvi (Roll No. 62), Sanket Suhagiya (Roll No. 76) and Rithwik Vedpathak (Roll No. 82)** submitted to the University of Mumbai in partial fulfillment of the requirement for the award of the degree of "**Bachelor of Engineering**" in "**Computer Engineering**".

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Project Report Approval for B.E

This project report entitled **'Online Exam Proctoring System'** by **'Bhumit Malvi, Sanket Suhagiya and Rithwik Vedpathak'** is approved for the degree of '**Bachelor of Engineering**' in '**Computer Engineering**'.

Examiners

1. _____

2. _____

Date:

Place:

Declaration

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Bhumit Malvi (62)

Sanket Suhagiya (76)

Rithwik Vedpathak (82)

Date:

Acknowledgements

It is said that “learning is a never-ending process.” While working on the project we have undergone the same experience of learning new things as we proceeded in our goal of building a Proctoring tool using Machine Learning.

Working on the project was a new experience for us. As it opened a new gateway wherein, we had an opportunity to work on a totally new concept as far as the engineering syllabus is concerned where most of the concepts are to be learned by rote.

The joy of working in a new domain and learning new things was a welcome experience for the three of us and all we have to say is that we have cherished all the moments as they came by, right from working on the project to making this report.

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We would like to thank **Prof. Smita Jawale,** who guided us and shared their knowledge & invaluable experience about the topic and gave their precious time towards solving our difficulties. We would also like to thank our college management for providing us with the facilities and infrastructure for working on the project.

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Date:

Abstract

Due to the lockdown environment, the world has shifted its normal practices to online modes. Due to which the exams for various schools, colleges face the problem of using a large number of personnel to proctor the students manually failing to ensure continuous integrity and security aspects of the examination. These results encouraging examinees to use unethical methods to score more in exams and falsely grading the knowledge and ability of a student. Also, in general, in online examinations, a human cannot proctor at large scales, effectively.

Thus, we are trying to create a proctoring system which can monitor at scale and ensure that examinees don’t practice cheating or other types of unethical behaviours.

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Chapter 1

Introduction

The current pandemic situation has forced colleges and schools to advance their ongoing curriculum. Technology played a pivotal role in leveraging the online mode of learning when the lockdown restrictions took place. As a result, many educational institutions transitioned to online test-taking as physical examinations were stalled, resulting in higher demand for online proctoring tools. Also, the exams for various schools, colleges face the problem of using a large number of personnel to proctor the students manually failing to ensure continuous integrity and security aspects of the examination and a human cannot proctor at large scales, effectively. This poses several issues like abnormal behaviour by the student, failing to ensure continuous integrity and security aspects of the examination like unauthorized access to different system components (e.g. cheating and malpractices). Although it allows students to take their tests online in a remote location while managing the integrity of the examination, this may also result in falsely grading the knowledge and ability of a student. Proposed system automates the proctoring process at scale with the aid of computers, and reduces the load on human proctors.

1.1 Aim and Objectives

Aim

To develop a computer vision enabled and AI powered system to aid a human proctor in various types of online examination. We use multimedia streams like video and audio from the user as our input data, which is further processed along with few system variables. These inputs are prepared and useful information is extracted, and finally fed into an algorithm which provides a probability of the user indulging into malpractices.

Objectives

Develop a proctoring system which will identify cheating behaviour:

- Efficiently
- Accurately
- Consume less resources and
- User Friendly

Chapter 2

Literature Review

An extensive Critical Review was conducted on 5 papers related to the field. The critical review was noted and an analysis Table was made.

2.1 Critical Review

[0] A Systematic Review of Online Exams Solutions in E-Learning: Techniques, Tools, and Global Adoption

1. In this paper a systematic review of existing literature was performed.
2. In this paper, 9 relevant questions were answered in the area of Online Proctoring:

- leading studies,
- online exam features,
- development approaches,
- techniques/algorithms,
- existing tools,
- datasets,
- country participation in research,

- key factors towards global adoption and
- challenges in research

[1] FaceNet: A Unified Embedding for Face Recognition and Clustering

This paper discusses efficient CNN based approach for

- face verification (is this the same person),
- recognition (who is this person) and
- clustering (find common people among these faces).

[2] Toward constructing a secure online examination system

- A basic framework of secure Online Examination System which can solve security problems with proper design of Online Examination webpage and network.
- The combination of firewall in the system server and proxy and MMC on the client system can be a security guarantee for the online examination system.

[3] Automated Online Exam Proctoring

- In this paper various techniques and algorithms are discussed related to online proctoring, including hardware requirements.
- Techniques include
    - user verification,
    - text detection,
    - speech detection,
    - active window detection,

- gaze estimation,
- phone detection and
- cheating behaviour detection.

[4] Implementation of e-proctoring in online teaching: A Study about Motivational Factors

- This study has sought to locate the motivational factors determining the implementation of the evaluation system.

- The list is made up of the following motivational factors:
  - Quality management (QM),
  - available information (AI),
  - external conditioning (EC),
  - trust (T),
  - perceived compatibility (PC),
  - perceived usefulness (PU),
  - attitude (A) and intention (I)

2.2 Analysis Table

In Analysis Table No. 2.1, a detailed analysis of the research papers has been conducted.

Table 2.1 Analysis Table

Title	Technique(s) Used	Conclusion
A Systematic Review of Online Exams Solutions in E-Learning: Techniques, Tools, and Global Adoption. [0]	Literature survey.	Found various existing online proctoring tools and their features.
FaceNet: A unified embedding for face recognition and clustering. [1]	Convolutional Neural Network.	Face verification, recognition and identification of common people among these faces was done.
Toward constructing a secure online examination system. [2]	Network security.	Security problem was discussed and solutions were proposed. Network security was also explored.
Automated Online Exam Proctoring. [3]	Discussion on various techniques and algorithms for various features required for proctoring.	Multimedia was used as basis for analytics for proctoring system.
Implementation of e-proctoring in online teaching: A Study about Motivational Factors. [4]	Locates the motivational factors determining the implementation of the evaluation system.	Limited to study of motivational factors, which could be eliminated by future studies.

2.3 Problem Definition

In online examinations, a human cannot proctor at large scales, effectively.

This poses several issues like abnormal behaviour by the student, failing to ensure continuous integrity and security aspects of the examination like unauthorized access to different system components (e.g., cheating and malpractices). This results in falsely grading the knowledge and ability of a student.

Proposed system automates the proctoring process at scale with the aid of computers, and reduces the load on human proctors.

Chapter 3

Project Description

The chapter has a complete description of the working and Implementation of the Project. A process diagram along with the algorithm used are shown here.

3.1 Modules

1) **Hardware Components:**

   We have assumed that the user will be attending the exam on a relatively modern system with Camera and microphone available. The major challenge with the hardware is that the complete detection and validation process is going to be processed on the user's client device which has limited processing resources. Thus, we have created light weight algorithms which can run on low spec devices. The computer will provide few important system parameters, the camera will provide raw video stream and the microphone will provide raw audio stream.

2) **Speech Detection**:

Speech is one of the communication mediums through which one can gain assistance for exams. We assume that the examinee is sitting in a quiet room with no one around. The major challenge in speech detection is false identification, since there might inheritably be some kind of sound in the environment, identifying it as assistance or not-assistance is a major challenge. We have tackled this issue with an audio processing algorithm developed in house. It detects the changes in amplitude of the background noise. It detects frequency of changes of amplitude relative to idle noise value to infer whether the examinee is or his accomplice is talking.

3) **Head-pose Detection:** The best way the supervisors use to detect abnormal behaviour is the check where the examinee is looking, we use the same concept in this project to detect the direction/angle of the head of the examinee. The major challenge is the computer vision algorithm used to detect the face using the images data as well as the direction of the head, such algorithms usually require large amounts of training data as well as discrete graphic hardware to work properly. We tackle this problem by using third party open-source algorithms from MediaPipe library by google which is designed to work on low end devices with accuracy at par. The MediaPipe library provides accurate face landmarks, these face landmarks are then processed by the Perspective-n-Points algorithm implemented with help of an open computer vision library to provide the 3D orientation of the user's head.

4) **Cheating Behaviour Detection:** This is the ultimate prediction algorithm which provides the final output of the analysis done. The major challenge is to contextually use the data points collected from individual modules of speech and video detections to ignore false positives. We process these extracted features on a light weight algorithm developed in house which provides the probability whether the used is cheating. The audio is analysed to detect the speech of the user using the amplitude of sound. Then this data is stored as a flag which shows whether the user is speaking or not. Head pose detection is used to detect whether the user is looking up, down, left or right. This is detected by applying a threshold over the head angle. If the user exceeds the angle then the two flags are used to store the head pose which are named x-axis and y-axis. Then the flags of x-axis, y-axis, sound and the previous output is fed into a probabilistic conditional algorithm to predict if the user is showing suspicious behaviour in terms of percentage of surety.

3.2 Process Diagram

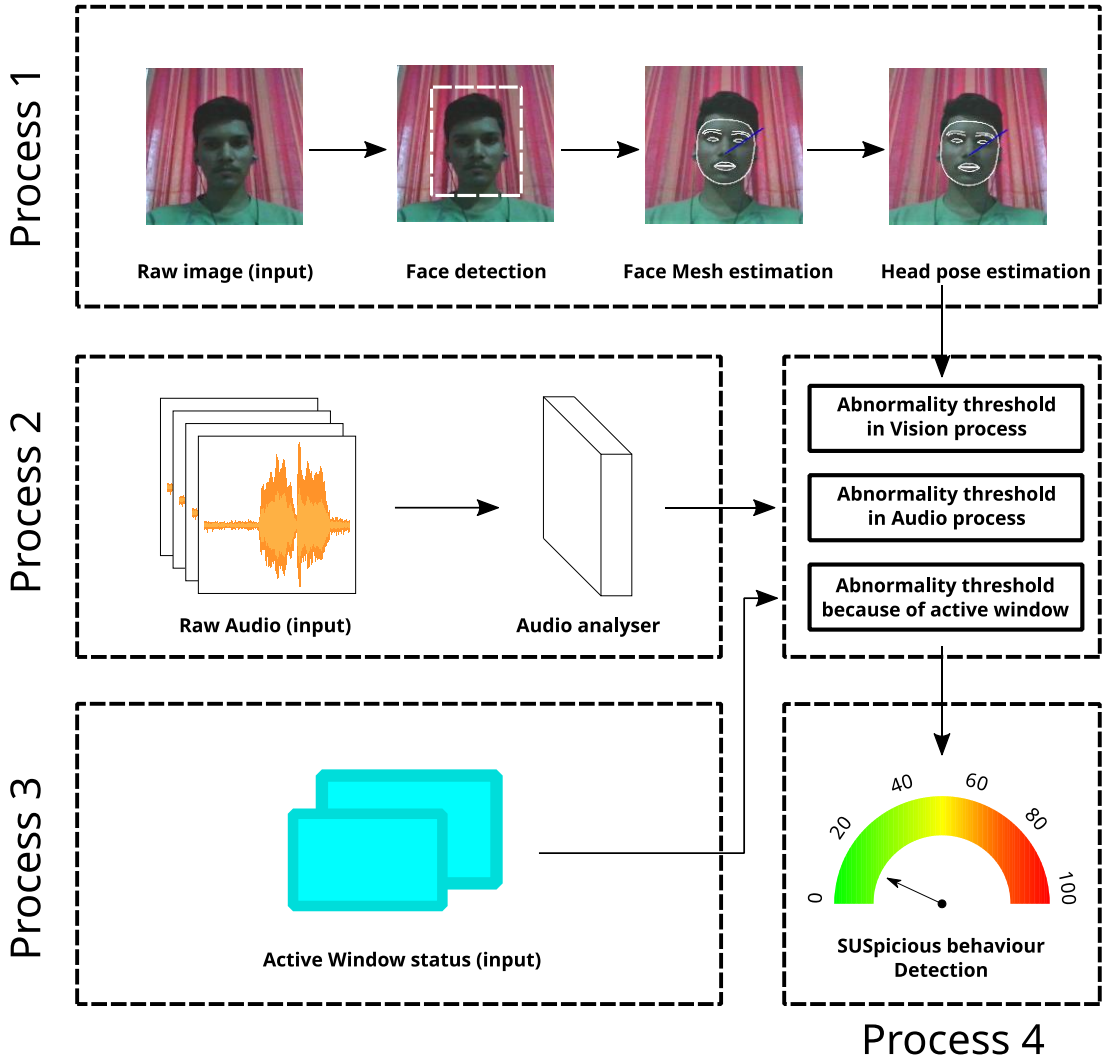

Figure 3.1 Process Diagram.

The process 1 does the head pose estimation of the module in which computer vision is used to get the angle of the head. Process 2 is used for speech detection; the audio is analysed using a sound processing algorithm which detects speech based on the amplitude of the sound recorded. process 3 is used to make sure that the user is currently on the exam window. Data is then fed in a conditional algorithm which gives the suspicious behaviour detection percentage based on set weightage.

3.3 Analysis

3.3.1 Functional Requirements

- Sensors to monitor the user.
- Processing the output of sensors.
- Giving feedback to the proctor based on sensor data.

3.3.2 Non-Functional Requirements

- Portability.
- Reliability and Security.
- Performance and Flexibility.
- Capacity and Scalability.
- Usability

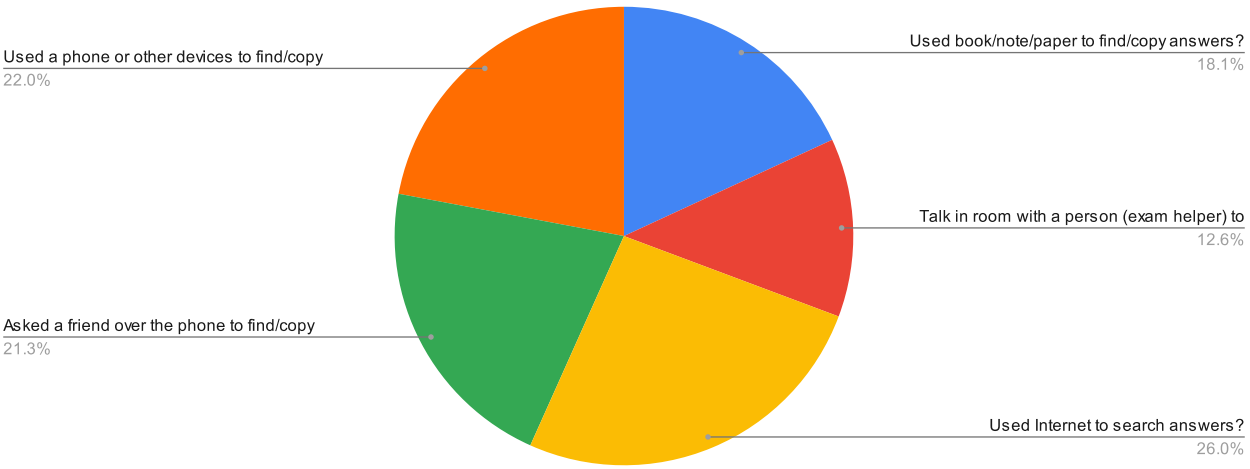

Figure 3.2 Analysis of cheating methods used (a survey).

3.4 Implementation Methodology

Three different methods are used in this proposed system which explain below:

- Head pose estimation
- Speech Detection
- Cheating Behaviour detection

For head pose estimation, we use OpenCV library for python for images capture and prepossessing. The MediaPipe library by Google is used for face recognition. It is an open-source ML library for various computer vision applications. We use the face recognition module to detect the face in the captured image. Then we use the PnP library to calculate the angle of the head and use that data to get the head angle data. We apply a threshold to the angle of the head pose on the X and Y axis such as if the user looks beyond the threshold, then it is detected as looking beyond the screen.

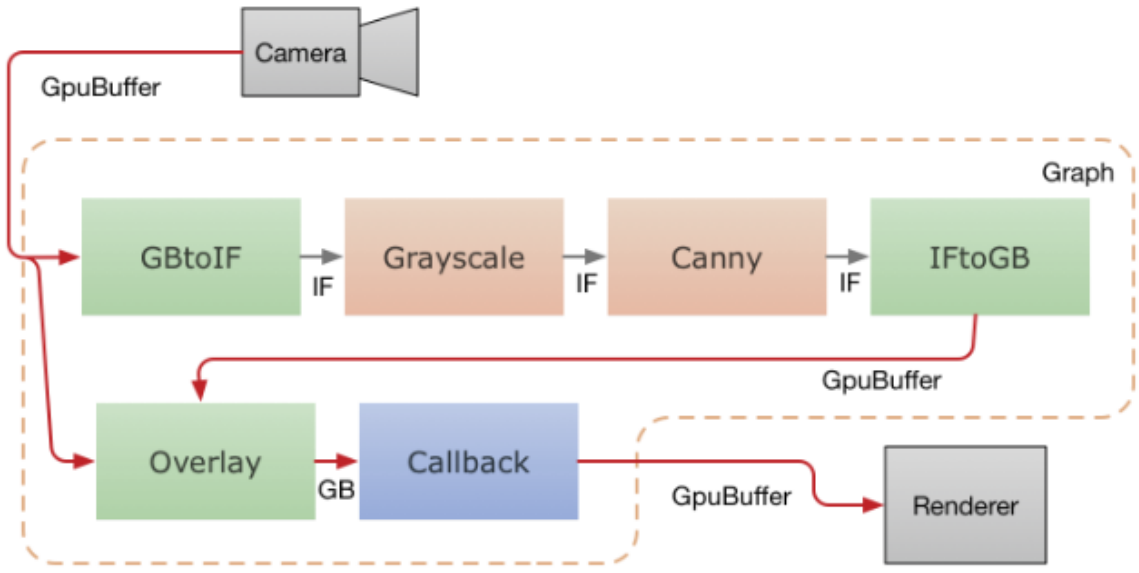

Figure 3.3 Face recognition algorithm processing.

If the user is looking right or left then the value of x-axis changes. If the user is looking left then it goes to the negative side of zero and if the user looks right then the value goes to the positive side of zero. And similarly, if the user looks up or down then the y-axis value changes. The values of x-axis and y-axis are then passed through an algorithm which checks whether it goes above the threshold then it changes the flag.

We detect audio in student's environment using sounddevice library in python. We use frames as input, and get its amplitude. Number of frames is monitored continuously and its amplitude is averaged out. If this average is greater than the threshold set by us over a period of time we consider it as suspicious behaviour and feed appropriate weights to our algorithm for further processing.

For suspicious behaviour detection we have used different flags pertaining to different inputs and these flags are then fed into a conditional algorithm which has set biases for different inputs. When a condition is satisfied, the resulting percentage output is added with a factor to the previous percentage to make the resulting percentage by time graph more continuous and not be in a step graph. When the suspicious percentage is above the set threshold then it is detected as cheating.

Previous Cheat	X axis	Y axis	Audio cheat	Final Cheat Percentage
0	0	0	0	0
0	0	0	1	0.2
0	0	1	0	0.2
0	0	1	1	0.4
0	1	0	0	0.1
0	1	0	1	0.4
0	1	1	0	0.15
0	1	1	1	0.25
1	0	0	0	0
1	0	0	1	0.55
1	0	1	0	0.55
1	0	1	1	0.85
1	1	0	0	0.6
1	1	0	1	0.85
1	1	1	0	0.5
1	1	1	1	0.85

Figure 3.4 Weightages for conditional algorithm.

3.5 Code

MAIN CODE

```
import audio
import head_pose
import detection
import threading as th

if __name__ == "__main__":
        # main()
        head_pose_thread = th.Thread(target=head_pose.pose)
        audio_thread = th.Thread(target=audio.sound)
        detection_thread = th.Thread(target=detection.run_detection)

        head_pose_thread.start()
        audio_thread.start()
        detection_thread.start()

        head_pose_thread.join()
        audio_thread.join()
        detection_thread.join()
```

AUDIO PROCESSING CODE

```
import sounddevice as sd
import numpy as np

# place holders and global variables
SOUND_AMPLITUDE = 0
AUDIO_CHEAT = 0

# sound variables
# SUS means next sound packet is worth analyzing
CALLBACKS_PER_SECOND = 38          # callbacks per sec(system dependent)
SUS_FINDING_FREQUENCY = 2          # calculates SUS *n* times every sec
SOUND_AMPLITUDE_THRESHOLD = 20     # amplitude considered for SUS calc

# packing *n* frames to calculate SUS
FRAMES_COUNT = int(CALLBACKS_PER_SECOND/SUS_FINDING_FREQUENCY)
AMPLITUDE_LIST = list([0]*FRAMES_COUNT)
SUS_COUNT = 0
count = 0

def print_sound(indata, outdata, frames, time, status):
        avg_amp = 0
        global SOUND_AMPLITUDE, SUS_COUNT, count,
      SOUND_AMPLITUDE_THRESHOLD, AUDIO_CHEAT
        vnorm = int(np.linalg.norm(indata)*10)
        AMPLITUDE_LIST.append(vnorm)
        count += 1
        AMPLITUDE_LIST.pop(0)
        if count == FRAMES_COUNT:
                avg_amp = sum(AMPLITUDE_LIST)/FRAMES_COUNT
                SOUND_AMPLITUDE = avg_amp
                if SUS_COUNT >= 2:
                        #print("!!!!!!!!!!!! FBI OPEN UP !!!!!!!!!!!!")
                        AUDIO_CHEAT = 1
                        SUS_COUNT = 0
                if avg_amp > SOUND_AMPLITUDE_THRESHOLD:
                        SUS_COUNT += 1
                        #print("Sus...", SUS_COUNT)
                else:
                        SUS_COUNT = 0
                        AUDIO_CHEAT = 0
                count = 0

def sound():
        with sd.Stream(callback=print_sound):
          sd.sleep(-1)
```

```
def sound_analysis():
        global AMPLITUDE_LIST, FRAMES_COUNT, SOUND_AMPLITUDE
        while True:
                AMPLITUDE_LIST.append(SOUND_AMPLITUDE)
                AMPLITUDE_LIST.pop(0)

                avg_amp = sum(AMPLITUDE_LIST)/FRAMES_COUNT

                if avg_amp > 10:
                        print("Sus...")

if __name__ == "__main__":
        sound()
```

Chapter 4

Result and Discussions

4.1 Result

After implementation of the project the project is evaluated and tested on various parameters. The results are listed and outputs are plotted accordingly.

For speech recognition we use sounddevice library in python to measure the intensity of the sound in the audio. We use OpenCV library for python for images capture and prepossessing. The MediaPipe library by Google is used for face recognition. It is an open-source ML library for various computer vision applications. We use the face recognition module to detect the face in the captured image. Then we use PnP library to calculate the angle of the head and use that data to get the head angle data. We apply a threshold to the angle of the head pose on the X and Y axis such as if the user looks beyond the threshold, then it is detected as looking beyond the screen.

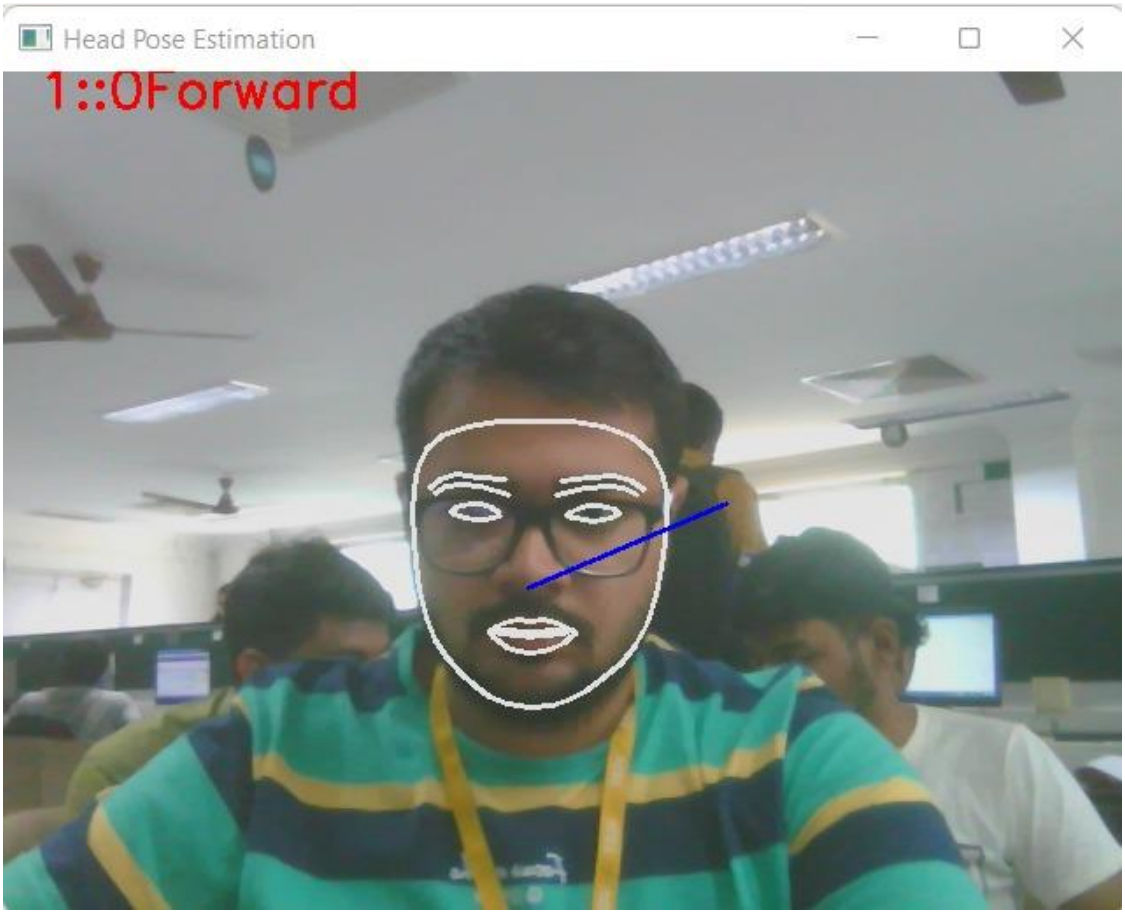

Figure 4.1 Result of head pose estimation.

For suspicious behaviour detection we used different flags pertaining to different inputs and these flags are then fed into a conditional algorithm which has set biases for different inputs. When a condition is satisfied, the resulting percentage output is added with a factor to the previous percentage to make the resulting percentage by time graph more continuous and not be in a step graph. When the suspicious percentage is above the set threshold then it is detected as cheating. The output is then plotted in a graph with time on X-axis and the percentage on Y-axis. The graph is continuous, which means it will update progressively as time goes by.

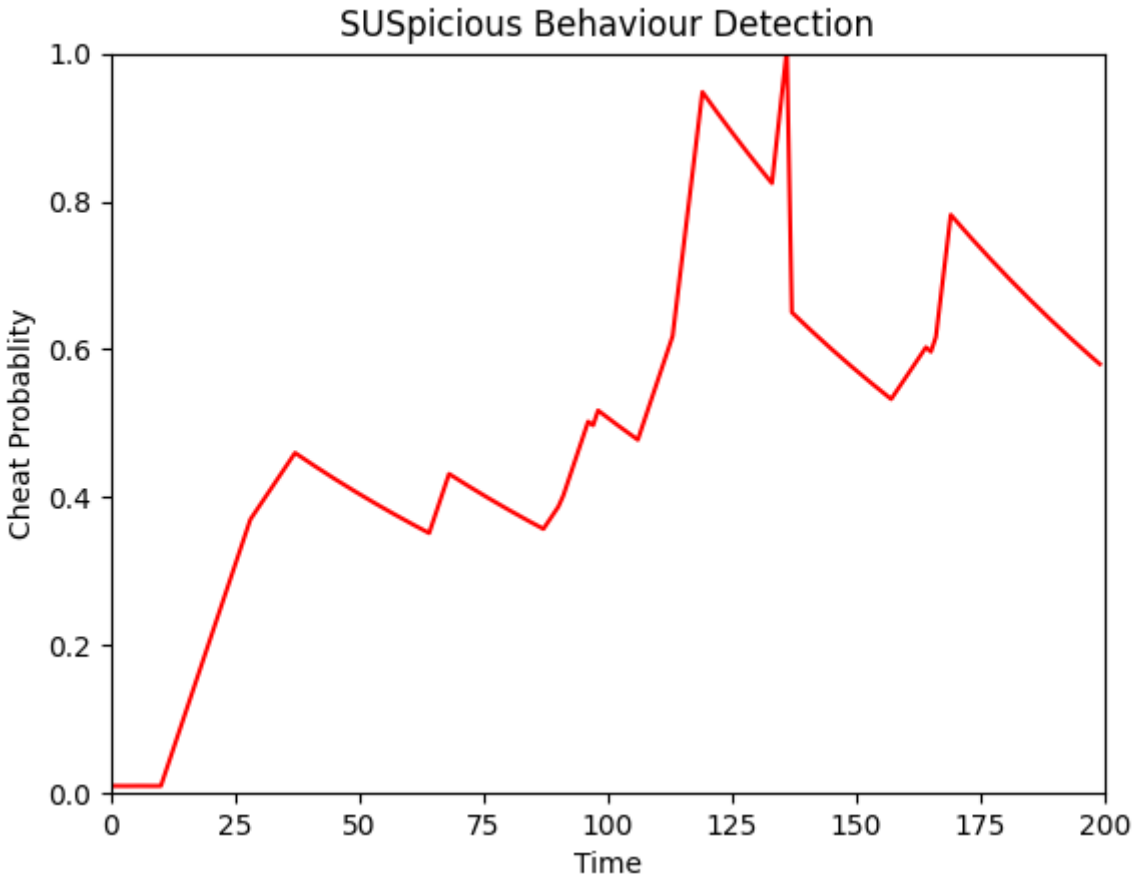

Figure 4.2 Result of suspicious behaviour detection.

4.2 Future Scope

In time, technology, dataset, and confidence of user will rise so that AI will be able to make autonomous judgments on the severity of a situation and then take appropriate action, such as ending or pausing an assessment.

Chapter 5

Conclusion

This system is one of the popular revisited topics due to pandemic and the need for people to conduct online tests. This system aimed to detect whether the user is showing suspicious paper using Video and audio output. During the making of the system, we used various machine learning algorithms for head pose detections and successfully implemented head pose estimation using computer vision as well as speech detection using microphone. We successfully developed a system which can detect suspicious behaviour and it is a light weight, low resource consuming system.

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[3] Y. Atoum, L. Chen, A. X. Liu, S. D. H. Hsu and X. Liu, "Automated Online Exam Proctoring," in *IEEE Transactions on Multimedia*, vol. 19, no. 7, pp. 1609-1624, July 2017, doi: 10.1109/TMM.2017.2656064.

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Publications

1. Published on ResearchGate.
2. Pending approval at 7th International Conference on Communication and Electronics Systems ICCES 2022

Competitions

1. “Online Exam Proctoring System”, VCET National Project Showcase 2022.